80/433/FDIS

FINAL DRAFT INTERNATIONAL STANDARD
PROJET FINAL DE NORME INTERNATIONALE

Project number Numéro de projet	**IEC 61924 Ed.1**	
IEC/TC or SC CEI/CE ou SC **TC 80**		Secretariat / Secrétariat **United Kingdom**
☒ Submitted for parallel voting in CENELEC Soumis au vote parallèle au CENELEC	Distributed on / Diffusé le **2006-02-10**	Voting terminates on / Vote clos le **2006-04-14**
Also of interest to the following committees Intéresse également les comités suivants	Supersedes document Remplace le document 80/408/CDV - 80/428/RVC	
Functions concerned Fonctions concernées ☐ Safety / Sécurité ☐ EMC / CEM ☐ Environment / Environnement ☐ Quality assurance / Assurance de la qualité		

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Title

IEC 61924-Ed.1: Maritime navigation and radiocommunication equipment and systems - Integrated navigation systems operational and performance requirements - Methods of testing and required test results

ATTENTION
VOTE PARALLÈLE
CEI – CENELEC

L'attention des Comités nationaux de la CEI, membres du CENELEC, est attirée sur le fait que ce projet finale de Norme internationale est soumis au vote parallèle.
Un bulletin de vote séparé pour le vote CENELEC leur sera envoyé par le Secrétariat Central du CENELEC.

ATTENTION
IEC – CENELEC
PARALLEL VOTING

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this final draft International Standard (DIS) is submitted for parallel voting.
A separate form for CENELEC voting will be sent to them by the CENELEC Central Secretariat.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – INTEGRATED NAVIGATION SYSTEMS – OPERATIONAL AND PERFORMANCE REQUIREMENTS, METHODS OF TESTING AND REQUIRED TEST RESULTS

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International Standard IEC 61924 has been prepared by IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.

The text of this standard is based on the following documents:

FDIS	Report on voting
80/XX/FDIS	80/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date[1] indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this standard may be issued at a later date.

1 The National Committees are requested to note that for this publication the maintenance result date is 2011.

INTRODUCTION

International Standard IEC 61924 has been developed by IEC Technical Committee 80 to clarify the IMO Resolution MSC 86(70) Annex 3 Recommendation on Performance Standards for an Integrated Navigation System (INS). This standard provides adequate requirements, methods of tests and required test results to facilitate type approval.

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – INTEGRATED NAVIGATION SYSTEMS – OPERATIONAL AND PERFORMANCE REQUIREMENTS, METHODS OF TESTING AND REQUIRED TEST RESULTS

1 Scope

This International Standard specifies the minimum requirements for the design, manufacture, integration, methods of testing and required test results for an integrated navigation system (INS) to comply with the International Maritime Organization (IMO) requirements of Resolution MSC 86(70) Annex 3. (See Annex A).

This standard aims to resolve conflicts that may occur from the differences in the requirements of the relevant IMO Performance Standards for individual navigational aids when forming part of the INS.

All text of this standard, whose meaning is identical to that in IMO Resolution MSC 86(70) Annex 3 will be printed in *italics* and the Resolution and paragraph number indicated between brackets.

This standard is applicable to an INS, that is any *combination of navigational aids that provides functions beyond the general intent defined in the respective performance standards adopted by the Organization for individual equipment* (MSC 86(70) Annex 3, 2.1).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60945:2002, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61162-1*, Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1: Single talker and multiple listeners*

IEC 61162-2, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 2: Single talker and multiple listeners, high-speed transmission*

IEC 61174:2001, *Maritime navigation and radiocommunication equipment and systems – Electronic chart display and information system (ECDIS) – Operational and performance requirements, methods of testing and required test results*

IEC 61209:1997, *Maritime navigation and radiocommunication equipment and systems – Integrated bridge systems (IBS) – Operational and performance requirements, methods of testing and required test results*

IEC 62065:2002, *Maritime navigation and radiocommunication equipment and systems – Track control systems – Operational and performance requirements, methods of testing and required test results*

IMO A.224(VII) as amended by MSC.74(69) Annex 4, *Performance standards for echo-sounding equipment*

IMO A.424 (XI), *Performance standards for gyro-compasses*

IMO A.529 (XIII), *Accuracy standards for navigation*

IMO A.694(17), *General requirements for shipborne radio equipment forming part of the Global maritime distress and safety system (GMDSS) and for electronic navigational aids*

IMO A.815(19), *World-wide radionavigation system*

IMO A.821(19), *Performance standards for gyro-compasses for high speed craft*

IMO A.823(19), *Performance standards for automatic radar plotting aids*

IMO A.824(19), *Performance standards for devices to indicate speed and distance*

IMO A.830(19), *Code on alarms and indicators*

IMO A.893(21), *Guidelines for voyage planning*

IMO 1974, *International Convention for the Safety of Life at Sea (SOLAS), as amended*

IMO MSC.64 (67) Annex 1, *Recommendation on performance standards for integrated bridge systems (IBS)*

IMO MSC.64 (67) Annex 4, *Recommendation on performance standards for radar equipment*

IMO MSC 86(70) Annex 3, *Performance standards for an integrated navigation system (INS)*

ISO 11674: 2000, *Ships and marine technology – Heading control systems*

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1
accuracy
degree of conformance between the estimated or measured parameter value at a given time and its true parameter value at that time

3.1.2
added value
functionality and information, which are provided by the INS, in addition to the requirements of the performance standard for the individual equipment

3.1.3
aid to navigation
any device or system external to a vessel intended to assist a navigator to determine position or safe course, or to warn of hazards to navigation

3.1.4
alarm
audible signal or audible and visual signal announcing a condition requiring immediate attention or user action

3.1.5
alarm management
functions provided by an INS for harmonising, processing, monitoring and distributing audible and visual announcements and their acknowledgement, silencing and cancelling operations

NOTE The alarm management function administers different levels of announcements: alarms, warnings and indications.

3.1.6
announcement
visual or audible signal issued to the user by the system

3.1.7
automatic control system
control system that may include a heading, track or speed control system

3.1.8
conning position
place on the bridge with a commanding view and which is used by navigators when commanding, manoeuvring and controlling a ship

3.1.9
consistent common reference point
location in a ship to which all measurements such as own ship's position, target range, bearing, relative course, relative speed, pitch and yaw are referred. Typically, this is the conning position on the bridge, but may, for example be the origin of the reference axes of the ship

3.1.10
consistent common reference system
CCRS
sub-system (or function) of an INS for acquisition, processing, storage and distribution of data and information, providing identical and obligatory reference to sub-systems within an INS. The CCRS is the means to ensure that all parts of the INS use the same source and values for a specific type of system data and essential information, for example own ship position, speed through water, heading, time, etc.

3.1.11
detected hazard
hazard identified by a sensor (for example, radar or echo sounder) or reported by a communication device (for example AIS or NAVTEX) and which is available to the INS

3.1.12
entry field
location on a display for the input of data by the operator. The requested information is usually alphanumeric

3.1.13
essential information
information required for the fundamental functions of the INS. This includes as a minimum position, speed, heading and time

3.1.14
expected precision
deviation between the measured value and the true value that is normally not exceeded by a typical system

3.1.15
functionality
ability to perform an intended function. The activity of performing a function normally employs a system of displays, controls and instrumentation

3.1.16
hazard
objects or conditions potentially dangerous to navigation, possibly leading to grounding or collision, that may be detected by a sensor, reported by a communication device, retrieved from a database or manually input to the INS

3.1.17
indication
visual information about the condition of a system or equipment

3.1.18
inspection
visual check of the equipment or documentation

3.1.19
integrated navigation system
combination of systems or functions of navigational aids that are interconnected to increase safe and efficient navigation when used by suitably qualified personnel

3.1.20
integrity
property of information as being accurate and valid with regard to specified requirements and verified by comparing data from more than one independent source

3.1.21
integrity monitoring
ability of a system to provide the user with information within the specified accuracy in a timely, complete and unambiguous manner, and alarms and indications within a specified time when the system should be used with caution or not at all

3.1.22
known hazard
hazard retrieved from a database (including navigational charts and nautical publications) or manually input and which is available to the INS

3.1.23
latency
time interval between an event and its result, including time for reception, processing, transmission and display

3.1.24
leg
the ship’s intended ground track between two waypoints

3.1.25
manufacturer
organisation responsible for the production of all or some of the parts of the INS, including the responsibility that these parts meet their individual international standards. A manufacturer may also be the system integrator

3.1.26
marking
visual or logical indication of the status of displayed or transferred information

3.1.27
mode
the setting of a group of parameters determining the behaviour (operational modes) or the Human Machine Interface (HMI) (display modes) or the control functions (control modes) of the equipment or its sensors

3.1.28
mode awareness
perception of the mariner regarding the currently active Modes of Control, Operation and Display of the INS including its subsystems, as supported by the presentations and indications at an INS display or workstation

3.1.29
multifunction display
single visual display unit that can present, either simultaneously or through a series of selectable pages, information from more than one operation of a system

3.1.30
navigation
process of planning, executing, monitoring and recording the progress of a safe and expeditious voyage of a vessel

3.1.31
navigational aid
ship-borne device that complies with its relevant International Standard(s), for example instrument, method or chart, intended to assist in the navigation of a ship.

3.1.32
part
individual INS subsystem, equipment or functional module

3.1.33
passage
process of moving a ship from one place to another by navigating through a certain area within a certain period of time and in compliance with certain environmental and legal provisions

3.1.34
performance check
functional check to show that the system or component is still operational without investigating all details of its functionality

3.1.35
plausibility
quality of being believable or trustworthy

3.1.36
primary navigation data/information
data of own ship's position, speed, heading, time and, in case of INS(B) and if available depth, provided by selected sensors, to be used in the system for processing the navigational information

3.1.37
route
representation of a voyage or passage geographically defined by a point of departure, a point of arrival and usually by intermediate waypoints. It may include time of departure and/or ship's speed as well as parameters and limits for safe navigation such as off-track limit, turn radius, time references, etc. and as defined in IMO Resolution A.893(21)

3.1.38
selected route or track
route or track which has been chosen for monitoring the performance of the navigation. The term “track” is typically used for systems that have automatic track control capability

3.1.39
sensor
navigational aid, with or without its own display and control as appropriate, automatically providing information to the INS

3.1.40
situation awareness
perception of the mariner regarding the prevailing nautical situation and the currently active or available system resources, as supported by the presentations and indications at an INS display or workstation. It includes mode awareness

3.1.41
system data
data that is used by the system for the processing and display of essential information. System data of the same type is from the same source. System data, at least for primary navigation information, has been checked for integrity

3.1.42
system integrator
organisation responsible for ensuring that the INS complies with the requirements of this standard

3.1.43
track
geographical representation of the movement actually performed by the ship, or, in case of a track control system, the path (over ground) to be (automatically) followed

3.1.44
validity
conformity of information with formal and logical criteria, or the marking of data as being good or no good (valid or invalid) for the intended use

3.1.45
vessel
water craft of any description, including non-displacement craft, WIG craft and seaplanes, used or capable of being used as a means of transportation on water

3.1.46
voyage
execution of all aspects of the operation of a craft in journeying from the point of departure to the final destination. A voyage may consist of one or more passages

3.1.47
warning
signal announcing a condition requiring non-immediate attention for precautionary reasons

3.1.48
waypoint
geographically defined position used as reference for navigation along a leg, track or route

3.1.49
workstation for INS or INS workstation
workstation at which display or operator control functions are provided to meet the requirements of this standard. An INS workstation need not be a physical part of the INS. It may just be the location where the necessary displays and controls are situated

3.2 Abbreviations

AIS	Automatic identification system
ARPA	Automatic radar plotting aid
ATA	Automatic tracking aid
AtoN	Aid to navigation
CCRS	Consistent common reference system
COG	Course over ground
DR	Dead reckoning
ECDIS	Electronic chart display and information system
EUT	Equipment under test
EPA	Electronic plotting aid
EPFS	Electronic position fixing system
GNSS	Global navigation satellite system
HCS	Heading control system
HMD	Heading measuring device
HMI	Human machine interface
IBS	Integrated bridge system
IMO	International Maritime Organization
IEC	International Electrotechnical Commission
INS	Integrated navigation system
ISO	International Organization for Standardization
LORAN	Long range navigation system
MSC	Marine Safety Committee
OOW	Officer in charge of the navigational watch (Officer of the Watch)
RAIM	Receiver autonomous integrity monitoring
ROT	Rate of turn
SDME	Speed and distance measuring equipment
SOG	Speed over the ground
SOLAS	Safety of life at sea
THD	Transmitting heading device

4 Functional requirements and application

NOTE Clarification of minimum requirements is given in Annex B.

4.1 General

In addition to meeting the relevant requirements of Resolution A.694(17) to which IEC 60945 is associated*, the INS* shall *comply with the requirements* of the IMO Performance Standards MSC 86(70) Annex 3, as clarified in this standard.

4.1.1 Purpose

The purpose of this standard *is to support proper and safe integration of navigational equipment and information*. (MSC 86(70) Annex 3, 2.2).

4.1.2 Purpose of an integrated navigation system (INS)

The purpose of an integrated navigation system (INS) is to provide 'added value' to the functions and information needed by the officer in charge of the navigational watch (OOW) to plan, monitor or control the progress of the ship (MSC 86(70) Annex 3, 1.1).

A functional description shall be provided with a description of how the INS ‘’added value’ is achieved.

4.1.3 Compliance

Each part of the INS shall comply with the applicable requirements adopted by IMO, including the requirements of IMO resolution MSC 86(70) Annex 3*. Parts executing multiple operations shall meet the requirements specified for each individual function they can control, monitor or perform*. (MSC 86(70), 4.1.2).

A sensor or part thereof is not part of the INS if it only supplies data and does not perform other functions of the INS as required by this standard.

An actuator and its associated control system or part thereof (for example steering gear control system, propulsion control system, fin stabilising system) is not part of the INS if it only receives data or commands and does not perform other functions of the INS as required by this standard.

4.1.4 Equipment required

The INS consists of the equipment that provides the functions going beyond the general intent of independent equipment and international standards and the additional equipment required to meet this standard.

4.1.5 Mode and situation awareness

The INS supports mode and situation awareness. (MSC 86(70) Annex 3, 1.2) within the scope of functions provided by the relevant category of INS(A), (B), or (C).

4.1.6 Three INS categories

If a combination of navigational aids has been determined to be an INS as per 4.1.4, one of the following INS categories applies.

4.1.7 INS(A)

The requirements of this standard for *INS(A)* (see 5) are applicable to any INS *that provides the minimum functional requirements of the INS, including a consistent common reference system.* (MSC 86(70) Annex 3, 2.3.1). *The INS(A), as a minimum, provides the information of position, speed, heading and time, each clearly marked with an indication of integrity* (MSC.86(70), 4.1.7).

4.1.8 INS(B)

The requirements of this standard for *INS(B)* (see Clause 6) are applicable to any INS *that, in addition to the functional requirements of INS(A), provides the information needed for decision support in avoiding hazards* (MSC 86(70) Annex 3, 2.3.2*). The INS(B) automatically, continually and graphically indicates the ship's position, speed and heading and, where available, depth* (see note) *in relation to the planned route as well as to known and detected hazards* (MSC.86(70), 4.1.8).

An INS(B) is any INS that includes a (geo-) graphical display for decision support in avoiding hazards, such as a radar, radar plotting aid or ECDIS, if:

- the additional functionality resulting from the combination of navigational aids goes beyond the general intent as defined in the respective performance standard;
- the category INS(C) as per 4.1.9 does not apply.

NOTE "where available, depth" means: if an echo sounder with suitable interface is installed and in use.

4.1.9 INS(C)

The requirements of this standard for *INS(C)* (see Clause 7) are applicable to any INS *that, in addition to the functional requirements of INS(B), provide the automatic control functions of heading, track or speed* (MSC 86(70) Annex 3, 2.3.3), *and monitor the performance and status of these controls* (MSC 86(70) Annex 3, 4.1.9).

4.1.10 Requirements for all categories

The requirements of this clause are applicable to all three categories of INS, except where otherwise stated. The requirements specific to INS(A), INS(B) and INS(C) are detailed in Clauses 5, 6 and 7 respectively. The relevant category of the INS shall be declared.

4.1.11 Passage execution

The function of passage execution in an Integrated Bridge system (IBS), as defined by IMO in Resolution MSC.64(67) Annex 1 and related IEC 61209, *may be performed by an INS* which should at least be an INS(B) (MSC.86(70), 1.5).

4.1.12 Safety of navigation support

The INS supports safety of navigation by evaluating inputs from several independent and different sensors, combining them to provide information giving timely warnings of potential dangers and degradation of integrity of this information. Integrity monitoring is an intrinsic function of the INS (MSC 86(70) Annex 3, 1.3) as required by its category INS(A), (B), or (C).

4.1.13 Consideration of human factors

The INS aims to ensure that, by taking human factors into consideration, the work load is kept within the capacities of the OOW and other mariners on the bridge in order to enhance safe and expeditious navigation and to complement the mariner's capabilities, while at the same time to compensate for their limitations (MSC 86(70) Annex 3, 1.4), as required by its category of INS(A), (B) or (C).

4.2 Basic functions

4.2.1 Combination, processing and evaluation

The *INS* shall *combine, process and evaluate data from all sensors in use* (MSC 86(70) Annex 3, 4.1.5) for obtaining information of speed, heading, position and time for the purposes of the integrity evaluation specified in 4.7.

4.2.2 Mode and situation awareness

The INS shall *support mode and situation awareness* (MSC 86 (70) Annex 3, 1.2) and shall fulfil this requirement through functional integration, processing and display by providing:

- validated data, where possible**,** of all connected navigation sensors (see 4.4.3);
- the specified INS information and its status, including modes of operation and display;
- changes to this information and appropriate alarms and indications, as required by the INS category.

4.3 Functional integration

The INS shall *provide functional integration meeting the following requirements* (MSC 86(70) Annex 3, 4.1.16) of this subclause.

4.3.1 Multifunction display

Where a display or control is presented on a multifunction display unit then these shall *be redundantly available* (MSC 86(70) Annex 3, 4.1.16.1). The failure of a single multifunction display shall not result in the loss of a function mandated by the carriage requirements of SOLAS.

4.4 Interfacing and data exchange

Interfacing to, and from, the INS shall comply with International Standards, namely IEC 61162 series*, as appropriate and applicable* (MSC 86(70) Annex 3, 7) as follows:

4.4.1 Interfacing stand-alone equipment

Stand-alone equipment, for which performance standards adopted by IMO exist, when connected to the INS, shall *comply with* the IEC 61162 series *as applicable, for data exchange and interfacing* (MSC 86(70) Annex 3, 4.1.12). Where no suitable IEC 61162 interface is defined, an alternative interface may be used. Details about the available interfaces and functions supported thereby shall be included in the installation manual. Where the datum reference sentence (DTM) is received in accordance with IEC 61162-1 then it shall be evaluated and processed accordingly.

4.4.2 Plausibility checks

Received or derived data that is used or distributed by the INS shall be checked for plausible magnitudes of values.

Examples:

- heading of 361° is not plausible;
- magnitudes of actual velocity greater than the maximum ship’s speed are not plausible (plausibility check with known parameter of ship’s dynamics);
- magnitude of actual ROT greater than the maximum ship’s ROT is not plausible (plausibility check with known parameter of ship’s dynamics).

Data which has failed the plausibility checks shall not be used by the INS and this shall not affect functions not dependent on these data (see Table 1).

4.4.3 Validity checks

Validity of the data shall be provided for each part to be integrated (MSC 86(70) Annex 3, 4.1.16.2).

The data received, used or distributed by the INS shall be checked for validity marking by the sensor. Data that has failed the validity checks shall not be used by the INS and this shall not affect functions not dependent on these data (see Table 1).

4.4.4 Integrity of data exchange

The integrity of the data exchange within the INS shall be ensured (MSC 86(70) Annex 3, 4.1.14) (see Table 1).

4.4.5 Data output

Data output from the INS shall comply with the IEC 61162 series as applicable. The sentences specified in Annex C of this standard shall be provided. Where no suitable IEC 61162 interface is defined proprietary sentences or an alternative interface may be used. Details about the available interfaces shall be included in the installation manual.

Where interfaces with IEC 61162-1 sentences are used:

- positional information shall be transmitted in the WGS84 datum using the datum reference sentence (DTM) in accordance with IEC 61162-1;
- system data and other data checked for integrity, modified or generated by the INS shall be transmitted with the talker identifier “IN”; otherwise the talker identifier of the source shall be used.

4.5 Accuracy and performance

As a minimum, the accuracy and other properties *of information* shall *meet the requirements of the resolutions adopted by* IMO[2] for the individual navigational aids connected to or forming part of the system. *Additionally the INS shall not degrade the accuracy of the data provided by the sensors* (MSC 86(70) Annex 3, 4.2.4).

NOTE Other properties may include update rate, range, resolution, validity, etc. as specified in the relevant standards.

4.6 Consistent common reference system (CCRS)

The INS shall *ensure that the different types of information are distributed to the relevant parts of the system, applying a ‘consistent common reference system’ for all types of information* (MSC 86(70) Annex 3, 4.1.6).

Information from the CCRS shall be:

a) referenced to same place and time;

b) compensated for latency as defined in 4.6.1;

c) checked for validity;

d) checked for plausibility.

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[2] IMO Resolutions A.529(13) and A.815(19)

The data shall be presented with a warning when it is not possible to perform the calculations required in a) and b). The data shall be marked as invalid if the tests c) or d) fail in accordance with Table 1.

The CCRS shall ensure that all parts of the INS are provided with the same type of data from the same source.

Ground velocity shall have its components (i.e. COG and SOG) derived from the same source.

Where data is presented that is not part of the CCRS, it shall be clearly identified as such.

4.6.1 Latency of data

Data latency shall *be consistent with the data requirements of the individual parts* (MSC 86(70) Annex 3, 4.1.13) and their relevant international standards.

4.6.2 Consistent common reference point

The INS shall use a single consistent common reference point for all spatially related information. For consistency of observed and measured ranges and bearings, the recommended reference location is the conning position.

Alternative reference locations may be used where clearly indicated or distinctively obvious.

The selection of an alternative reference point shall not affect the integrity monitoring process.

4.7 Integrity monitoring

The integrity of essential information shall *be* monitored and *verified* automatically *before essential information is displayed or used* (MSC 86(70) Annex 3, 4.1.11).

The integrity of data from different sensors shall *be evaluated prior to distribution* to other parts of the INS or to external devices (MSC 86(70) Annex 3, 4.1.5).

The INS shall provide capabilities to select the most accurate method of integrity monitoring from the available sensors.

The INS shall be capable of manual or automatic selection of sources for integrity monitoring.

A clear indication of the sources of data selected for integrity monitoring shall be provided. The INS shall be capable of accepting multiple sensor inputs for sensors providing the following data:

- heading;
- speed through water;
- EPFS position;
- time (e.g. from GNSS);
- velocity over ground (e.g. from EPFS).

Where RAIM is used for integrity monitoring, this shall be indicated.

4.7.1 Verification of data integrity

The integrity of information selected for use by the INS shall *be verified by comparison of the data derived independently from two or more sources if available* (MSC 86(70) Annex 3, 4.1.10).

4.7.1.1 Verification of position integrity

The INS shall be capable of monitoring the position integrity by all of the following means:

- comparison with a second EPFS;
- processing an output of the RAIM GNSS function;
- dead reckoning using the ship's heading and speed measuring device as input data to detect position jumps.

NOTE Comparison with dead reckoning position shall take into account the limitations of using water-referenced velocities and further limitations when the ship is turning or operating at low speeds (see also 4.7.2.1).

4.7.1.2 Verification of heading integrity

The INS shall be capable of monitoring the heading integrity by both of the following means:

- comparison with a second heading sensor;
- comparison with a course over ground sensor.

NOTE Where heading integrity is monitored by comparison with a course over ground sensor, the limitations at low speeds, in conditions of drift and when the ship is turning must be taken into account (see also 4.7.2.1).

4.7.1.3 Verification of speed through water integrity

The INS shall be capable of monitoring the speed through water integrity by both of the following means:

- comparison with a second speed through water sensor;
- comparison with a speed over ground sensor.

NOTE Where speed through water integrity is monitored by comparison with a speed over ground sensor, the limitations at low speeds, in conditions of drift and when the ship is turning must be taken into account. (see also 4.7.2.1).

4.7.1.4 Verification of velocity over ground integrity

The INS shall be capable of monitoring the velocity over ground integrity by all of the following means:

- comparison with a second velocity over ground sensor;
- comparison with a speed through water sensor;
- comparison with ground velocity from an EPFS.

NOTE Where velocity over ground is monitored by comparison with a speed through water sensor, the limitations at low speeds, in conditions of drift and when the ship is turning must be taken into account. (see also 4.7.2.1).

4.7.1.5 Verification of time integrity

The INS shall be capable of monitoring the integrity of the time data by both of the following means:

- comparison with a second sensor providing time data;
- comparison with the INS internal clock data.

4.7.1.6 Verification of depth integrity

The INS shall be capable of monitoring the integrity of the depth data by both of the following means:

- comparison with a second depth sensor;
- comparison with electronic chart data.

4.7.2 Integrity monitoring thresholds

The status of the data verified for integrity shall be marked “integrity check failed” when the difference between the sources exceeds pre-defined thresholds.

The threshold for integrity calculations shall be based on the specified or expected (where not specified) sensor accuracy at a probability of 95 %. The threshold may be determined by the geometric addition of the accuracy values of the data being used for integrity monitoring.

The integrity monitoring thresholds in use shall be available for display.

4.7.2.1 Adaptation of integrity monitoring thresholds

The INS may provide manual or automatic adjustment of the monitoring thresholds to take into account:

- inherent differences in availability, accuracy and response times of the data used for integrity monitoring; and
- different manoeuvring conditions.

The thresholds shall be limited to maximum values as stated in the manufacturer’s documentation.

4.8 Marking of data

4.8.1 Marking of data after integrity check

The data shall be marked with the result of integrity monitoring to enable subsequent functions to decide whether their input data complies with their integrity requirements or not.

Information with doubtful integrity shall *be clearly marked by the INS and* shall *not be used for automatic control systems* other than for fall-back purposes as described in 4.12.2 (MSC 86(70) Annex 3, 4.1.11).

4.8.2 Marking of doubtful data

The status of the data shall be marked "doubtful" when the integrity check has not been carried out.

4.8.3 Marking and use of sensor data

Table 1 defines the marking and use of data that have been checked for validity, plausibility and integrity within the INS. The specified announcement shall be raised for sensors that are in use.

Table 1 – Marking and use of data

Validity	Plausi-bility	Integrity	INS data marking	Announcement	Result
Fail	Any	Any (not relevant)	Validity check failed (doubtful integrity)	Alarm or warning as required by 4.9.1	Data cannot be used within INS
Any	Fail	Any (not relevant)	Plausibility check failed (doubtful integrity)	Alarm or warning as required by 4.9.1	Data cannot be used within INS
Pass	Pass	Impossible due to lack of secondary sensor, etc.	Integrity check not performed (doubtful integrity)	Alarm or warning as required by 4.9.2	Data cannot be used for automatic control function(s)
Pass	Pass	Fail	Integrity failed	Alarm	Data cannot be used for automatic control function(s)
Pass	Pass	Pass	Integrity passed	None	Data is suitable for any use

4.9 Generation of alarms and warnings

4.9.1 Indication of invalid information

When data required by the INS for essential information or for a required control function is invalid, corrupt or unavailable, an alarm shall be given. When non-essential information used by the INS is invalid, corrupt or unavailable, this shall be indicated at least as a warning.

4.9.2 Impossible integrity verification

The INS shall provide a warning if integrity verification is not possible. In the case of INS(C), an alarm shall be given if functioning in an active control mode.

4.10 INS display

4.10.1 Display of available information

The INS shall *be able to display the information in accordance with* its INS category as required by this standard. The display required for presentation of this information may be a dedicated display or a display of any available navigational aid. The display of such navigational aid then forms part of the INS.

4.10.2 Display of essential information

The following information shall be displayed simultaneously upon a simple operator command:

- essential information, (see 3.1.13 for definition);
- depth of water under keel (in case of INS(B) and (C));
- display mode (where not distinctively obvious);
- mode of operation (where not distinctively obvious).

Supplementary information related to the essential information shall *be readily accessible* (MSC 86(70) Annex 3, 5.2.3).

4.10.3 Content of information for display

Where the information may be ambiguous, *the information* shall *be displayed together with the indication of its:-*

- source*;* (sensor data, e.g. GYR 1, GYR 2, GPS 1, GPS 2, LORAN, EM log, Doppler log, radar 1, radar 2 etc.);
- *result of calculation or manual input;*
- *unit of measurement;*
- *status, including mode (see also integrity monitoring,* 8.5.10*).* (MSC 86(70) Annex 3, 4.2.3).

4.10.4 Display of additional information

Additional navigational information may be displayed provided it does not mask, obscure or degrade essential information required for display by this standard.

4.10.5 Display of sensor output data

The INS shall *be capable of displaying* information from the *output data available from the sensors* (MSC 86(70) Annex 3, 4.2.2).

4.11 Configuration display

It shall *be possible to display the complete system configuration, the available configuration and the configuration in use* (MSC 86(70) Annex 3, 4.1.17), as a graphic presentation or as a list. The information shall be detailed to the level of INS subsystems, sensors, and other equipment connected, ready for providing information to the INS, or used by the INS.

4.12 Malfunctions

4.12.1 Failures

4.12.1.1 Failure effects

A failure of one part shall *not affect the functionality of other parts except for those functions directly dependent upon the information from the defective part* (MSC 86(70) Annex 3, 4.1.4).

In case of failure in one part, it shall be possible to operate each other individual (i.e. not directly dependant) item of equipment or part of the system separately (see SOLAS V/19.6).

4.12.1.2 Malfunction of additional facilities

When equipment or *functions of equipment connected to the INS provide facilities in addition to this International Standard, the operation and as far as is reasonably practicable, the malfunction of such additional facilities* shall *not degrade the performance of the INS below the requirements of* this standard (MSC 86(70) Annex 3, 4.1.3).

The manufacturer shall declare all such additional facilities.

4.12.1.3 Failure of one part

A failure of one part shall be indicated by an alarm if this failure requires immediate operator attention as defined and documented by the manufacturer. Other failures shall at least be indicated as warnings.

4.12.1.4 Automatic response to malfunctions

The system's automatic response to malfunctions shall *result in the safest of any other configuration* or mode of operation as documented by the manufacturer, *accompanied by clear indications and alarms* (MSC 86(70) Annex 3, 4.3.1). The automatic response to malfunctions shall be in compliance with the relevant equipment standards.

4.12.2 Fall-back arrangements

The INS shall*, after a failure,* or when sensor data become invalid, *support the availability of essential information* and functions *through the use of appropriate fall-back arrangements* (MSC 86(70) Annex 3, 8.1) as given in the following subclauses.

NOTE For INS(C) the control related fall-back requirements are specified in the relevant standards, for example IEC 62065 and ISO 11674.

4.12.2.1 Independent functionality

A failure of data exchange between parts of the INS shall *not affect any independent functionality* of parts (MSC 86(70) Annex 3, 4.1.15).

4.12.2.2 Restored operation

Normal operation, after use of a fall-back arrangement, shall only be restored upon confirmation by the operator (MSC 86(70) Annex 3, 8.2).

Power interruption or intentional shut down is not to be treated as a fall-back condition (see 4.15.4.2).

4.13 INS alarm management

4.13.1 Alarm management system

An alarm management system shall *be provided* (MSC 86(70) Annex 3, 4.3.3.)

The INS alarm management system shall, in addition to meeting the relevant requirements of IMO Resolution A.830(19) as amended and IEC 60945, comply with the requirements of this standard.

The number of alarms shall *be kept as low as possible by providing indications for information of lower importance* (MSC 86(70) Annex 3, 4.3.5).

The announcement and the acknowledgement functions of the INS alarm management system may be performed by a centralised ship alarm management system. In this case or in the case where the centralised ship alarm management system takes over functions of the INS alarm management system, this functionality shall at least meet the relevant requirements of these standards.

The INS alarm management system shall have the capability of replacing the announcement functions of individual navigation equipment. These announcement functions shall, in addition to meeting the requirements of the performance standards specified for each individual equipment, comply with this standard.

All INS alarms and indications of their sources shall be provided at the navigation and manoeuvring workstation. The manufacturer’s documentation shall include guidance showing the physical layout of the INS alarm management system required to meet this requirement.

4.13.2 Generation of alarms, warnings and indications

Alarms, warnings and indications shall be as per Annex D.

4.13.2.1 Alarm delay

In order not to generate unnecessary alarms and fall-back situations for short term sensor errors, the generation of alarms and warnings for invalid or doubtful data may be delayed for a time period of up to 30 s. In such cases however, at least an indication shall be generated within a maximum time delay of 5 s.

If relevant, the manufacturer shall provide guidance in the documentation for setting of the time delays.

4.13.3 Alarm, warning and indication announcement

Methods of announcement as described in Table 2 shall be provided within the INS.

4.13.3.1 Alarm

The audible signal shall continue until the alarm condition is acknowledged or the audible signal is silenced.

The visual signal shall continue until the alarm condition is removed and the alarm is acknowledged.

Visual signals for unacknowledged and acknowledged alarm conditions shall be clearly distinguishable from each other.

If the alarm condition is removed prior to acknowledgement, audible and visual indication shall be removed after its acknowledgement.

NOTE Multiple cancellation of an alarm which is no longer valid should not be necessary, i.e. if an alarm is triggered 3 times before acknowledgement, it should not require 3 acknowledgements to clear it.

4.13.3.2 Warning

The audible signal shall not exceed 2 s and the audible level shall be as defined in IEC 60945 but may be adjustable below this limit.

The visual signal shall continue until the warning condition is removed and the warning is acknowledged (if an acknowledgement is required).

The visual signals for unacknowledged and acknowledged warning conditions shall be clearly distinguishable from each other.

4.13.3.3 Indication

The visual signal shall continue until the indication condition is removed.

Table 2 – Announcement for conditions requiring attention

Announcement for conditions requiring attention		ALARM	WARNING	INDICATION
Type of announcement	Audible and visual	X*	X*	--
	Visual only	--	--	X
Acknowledgement	Acknowledge local	X	O	--
	Acknowledge remote 1	X	O	--
	Acknowledge remote 2**	O	O	--
	Acknowledge remote 3**	X	X	--
Audible announcement silencing	Silence local	O	--	--
	Silence remote 1**	X	--	--
	Silence remote 2**	O	--	--
* The audible announcement shall be clearly and unambiguously distinguishable between ALARM and WARNING.				
** Where supported by the interconnected equipment.				
X Required function O Optional function -- Non-applicable function				
NOTE Other definitions are given in Table 3.				

Table 3 – Alarm acknowledgement/silencing definitions

Acknowledge local	Acknowledgement carried out on any operating panel which is directly assigned to the function generating the announcement and where the cause of the announcement and related information for decision support are presented
Acknowledge remote 1	Acknowledgement carried out on any workstation inside the INS where the cause of the announcement and related information for decision support are presented
Acknowledge remote 2	Acknowledgement carried out on an alarm panel of a centralised Ship Alarm Management System to which the INS is connected and where that panel also presents the source or cause of the announcement and related information for decision support
Acknowledge remote 3	The acknowledgement and the cancellation of the announcement occur automatically after the function generating this announcement is switched off (e.g. automatic control mode is switched off)
Silence local	Silencing carried out on the operating panel which is directly assigned to the function generating the announcement
Silence remote 1	Silencing carried out on any navigation and manoeuvering workstation inside the INS where the source or cause of the announcement are presented
Silence remote 2	Silencing carried out on an alarm panel of a centralised Ship Alarm Management System to which the INS is connected where that panel also presents the source or cause of the announcement

4.13.4 Display of alarms, warnings and indications

Alarms, warnings and indications shall be presented in accordance with relevant presentation standards.

Alarms shall *be displayed so that the alarm reason and the resulting functional restrictions can be easily understood* (MSC 86(70) Annex 3, 4.3.6).

The display of alarms, warnings and *Indications* shall *be self-explanatory* (MSC 86(70) Annex 3, 4.3.6).

4.13.5 Back-up officer alarm

The INS shall provide an interface for a back-up officer alarm, at least for those alarms required by the individual standards. The back-up officer alarm shall be initiated, when an alarm has not been acknowledged within 30 s. Acknowledgement of a back-up officer alarm shall only be possible from a location on the ship's bridge. The installation manual shall include appropriate details.

4.13.6 Standby alarm mode

The INS may provide a mode to avoid or suppress alarms, warnings and audible signals when the ship’s bridge is not required to be manned, for example when the ship is moored. This mode shall be clearly and continuously indicated and shall be activated and deactivated on operator action only. Implementation and cancellation of the standby alarm mode shall only be possible from a location on the ships bridge. Automatic control functions shall not be allowed in the alarm standby mode.

4.13.7 Alarm limit consistency

The INS shall support consistency of alarm limits used in different parts of the INS.

Where practicable, the INS shall, by automatic means, ensure that consistent limits are used by the different parts of the INS.

Where the automatic means are intentionally superseded by manual settings on different parts and when the automatic means are not practicable, an indication or warning shall be given when an alarm limit different from limits set in other parts are entered by the OOW.

4.14 Human machine interface (HMI)

Integrated display and control functions shall *adopt a consistent HMI philosophy and implementation* (MSC 86(70) Annex 3, 5.1.1), *paying particular attention to symbols, control*s *and layout* (MSC 86(70) Annex 3, 5.2.1). *Continuously displayed information shall be optimised* for good readability and operator perception.

The INS control functions, symbology and display layout shall comply with the requirements of International Standards, as relevant, and where not specified therein, individual equipment standards.

4.14.1 Information display

The HMI shall *be so designed that the provided information is clearly understood* and uses *a consistent presentation style* (MSC 86(70) Annex 3, 5.1.2). The HMI shall be consistent and conform to IEC 60945 and relevant International Standards.

4.14.2 Manual inputs

The HMI shall *be so designed that the requested manual inputs can be easily executed* (MSC 86(70) Annex 3, 5.1.3). The method of manual data entry shall comply with IEC 60945 and relevant International Standards.

4.14.3 Input errors

For manual inputs that may cause unintended results, and which may lead to excessive sudden manoeuvres or loss of data, *the INS shall request confirmation* and provide user guidance *before acceptance*, *thus providing* the operator the time for *a plausibility check* (MSC 86(70) Annex 3, 5.1.4).

4.14.4 Physical layout of operational controls

The INS shall *be designed and implemented so that the OOW can easily operate basic functions from INS workstations* (MSC 86(70) Annex 3, 5.2.2). The manufacturer's documentation shall include guidance showing the physical layout of the operational controls to meet this requirement.

4.15 Power supply

4.15.1 Power supply requirements

Power supply requirements applying to parts of the INS as a result of other IMO requirements, shall *remain applicable* (MSC 86(70) Annex 3, 6.4).

4.15.2 Power sources

The INS shall *be supplied*:

- *from both the main and emergency source of electrical power with automated changeover through a local distribution board with provision to preclude inadvertent shut down; and*
- *from a transitional source of electrical power for a duration of not less than 45 s* (MSC 86(70) Annex 3, 6.5).

The manufacturer shall describe the means necessary to meet the above in the installation manual.

4.15.3 Orderly shut down

If subjected to an orderly shutdown, the INS shall, upon turn on come to an initial default state ready for operation. The orderly shut down procedure, turn on procedure and the initial default state shall be provided/declared by the manufacturer.

4.15.4 Power interruption

4.15.4.1 Recovery time

After a power interruption full functionality of the INS shall *be available after recovery of all subsystems. The INS* shall *not increase the recovery time* beyond that specified in the standards *o*f the *individual subsystem* or its *functions after power restoration* (MSC 86(70) Annex 3, 6.6).

4.15.4.2 Functions after recovery

If subjected to a power interruption the INS shall*, upon restoration of power maintain the configuration* and mode *in use and continue automated operation, as far as practicable* or as specified in the individual equipment standard. *Safety related automatic functions*, for example automated steering control, shall *only be restored upon confirmation by the operator*. (MSC 86(70) Annex 3, 6.7).

4.16 Failure analysis

A failure analysis, at functional level, shall *be performed and documented for the proposed INS which includes all parts connected to or integrated into the system, including devices for manual override of automatic functions and their proposed locations on the bridge* (MSC 86(70) Annex 3, 6.2), as given in the following subclauses.

4.16.1 Failure analysis block diagram

The failure analysis shall refer to block diagram(s) in an appropriate format to enable the failure effects to be understood. The block diagram(s) shall illustrate the interrelationship and functional interdependence of the system elements.

4.16.2 Failure analysis elements

The failure analysis shall include the following items:

- identification of sensors, controllers and actuators connected to the INS or parts of the INS;
- possible failures, performance degradations and their causes for each individual equipment;
- the local effect on the individual equipment and the end effect on the INS or ship system level;
- method of failure detection at the individual equipment and/or the INS system including related alarms, warnings and indications;
- system related corrective action including fall-back mode(s) of operation (as applicable) and associated indications;
- indication of potentially hazardous failures.

4.17 Quality assurance

The integrator of the complete system and the manufacturers of the navigational aids being parts of the system shall have a Quality Control System audited by a competent authority to ensure continuous compliance with the requirements of this standard (see SOLAS V/18.5).

4.18 Manuals

In addition to the IEC 60945 requirements, adequate information shall be provided for the INS, as given in the following subclauses.

4.18.1 Operating manuals

Operating manuals shall include:

- an overall functional description of the INS, including a description of the ‘added value’ provided (see 4.1.2), as compared with relevant stand-alone navigational aids;
- the redundancy concept and the availability of functions;
- a description of possible failures and their effects on the system (for example by using part of the failure analysis as 4.12.1.1);
- guidance for the adjustment of the limits for alarms and warning indications;
- the implications of using different reference locations (see 4.6.2);
- details of the integrity monitoring provided by external sensors or subsystems and their required settings (see 4.7);

- details of the mechanism for marking valid, doubtful and invalid data (see 4.4.3);
- for INS(C), details of the external override and/or bypassing devices used in the reversionary mode (see 7.3).

4.18.2 Installation manuals

The installation manuals shall include adequate information to allow *the* INS to be *installed so that it can meet the requirements of the relevant International Standards* (MSC 86(70) Annex 3, 6.3) and additionally the installation manuals shall include the following:

- details of sensors, components and the interconnections forming the INS which are necessary to meet this standard;
- details of the interfaces and connections for data import and export and the interconnection diagrams and interfacing details for external parts of the INS and for devices to be connected;
- instructions for the installation and connection of facilities for alarm acknowledgement and cancellation including the back-up officer alarm in the case of INS(C);
- the details of the power supply arrangements required in accordance with 4.15;
- for INS(C), details of the installation and connection of external override and/or bypassing devices used in the reversionary mode (see 7.3); and
- recommendations on the physical layout of equipment (see 4.14.4).

5 Requirements applicable to INS(A)

The INS(A) shall*, as a minimum, provide the information of position, speed, heading and time, each clearly marked with an indication of integrity* (MSC 86(70) Annex 3, 4.1.7), as specified in 4.7.1.1 to 4.7.1.5 above.

6 Requirements applicable to INS(B)

6.1 General

INS(B) shall, in addition to the functional requirements of INS(A), *be able to automatically, continually and geographically indicate the nautical situation including the ships position, speed and heading and, where available, depth in relation to the ship's route, as well as to known and detected hazards* (MSC 86(70) Annex 3, 4.1.8).

NOTE Known hazards and detected hazards are defined in Clause 3.

6.2 Route planning and route monitoring

Route planning and route monitoring shall be according to IEC 61174 (ECDIS).

7 Requirements applicable to INS(C)

The INS(C) shall, in addition to the functional requirements of INS(B), provide means to automatically control heading, track or speed and monitor the performance and status of these controls (MSC 86(70) Annex 3, 4.1.9).

7.1 Heading or track control system

For the purpose of heading control, the INS(C) shall comply with the requirements specified in ISO 11674.

For the purpose of track control or track and speed control, the INS(C) shall comply with the requirements specified in IEC 62065.

7.2 Operator control and display functions

Where multiple workstations provide heading, speed, or track controls, only one workstation shall at any time be assigned to accept control commands. It shall clearly be indicated, if not otherwise obvious, if a workstation is not assigned to accept such control commands, at least upon an attempt to access the control. If a workstation includes such controls, it shall not be possible to prevent the workstation from taking control.

7.3 Reversionary mode

The INS shall *allow simple and effective operator action to override or by-pass any automated functions* (MSC 86(70) Annex 3, 4.3.2*)* regardless of the operational mode and failure status of the INS. This shall be a single operator action.

After changing from an automatic control mode to a reversionary mode the *INS* shall *resume* the original *automatic functions only after an appropriate message and intended operator action,* i.e. operator confirmation of the command, thus allowing the operator the opportunity *of considering all necessary starting conditions* (MSC 86(70) Annex 3, 4.3.2).

8 Test requirements and results

8.1 General

The manufacturer shall declare the equipment to be tested. The equipment under test (EUT) shall be installed in compliance with the manufacturer's installation manual. Where equipment is divided the entire configuration shall be tested together.

The manufacturer shall declare the:

- physical parts involved;
- location of functionality;
- general data flow between physical and/or logical parts;
- dependencies between functions.

8.2 Exceptions for tests previously performed

Where parts of an INS have been tested and documented as meeting individual International Standards (for example through individual type approvals), there is no requirement to repeat such testing. In such cases, sufficient information (for example certificates, test reports) shall be provided.

8.3 Test site

Unless otherwise stated all tests in this section are to be executed in a laboratory environment with a simulator. Tests will normally be carried out at test sites accredited by the test authority.

A simulator with the following characteristics is required:

- capable of providing position, speed, heading, time and, in the case of INS(B) depth simultaneously from multiple sources;
- capable of simulating own ship manoeuvres;
- capable of simulating failures in sensors, including RAIM failures in the case of GNSS;
- capable of simulating corrupt and implausible data;

- capable of simulating short and long term discrepancies between sensors;
- capable of simulating set and drift;
- capable of simulating AIS and radar.

In the case of an INS(C), the simulator shall be capable of testing to the requirements of IEC 62065, 5.2.1.

The resolution and accuracy of the simulated signals shall be in accordance with the applicable International Standards. The output signals shall comply with IEC 61162 and with the types of interfaces supported by the EUT according to the manufacturer's declarations.

8.4 Documentation check

Check that the following documentation is presented for assessment:

- evidence of INS parts compliance with individual standards (see 4.1.3);
- failure analysis in compliance with 4.16;
- evidence of compliant quality control system (see 4.17);
- operating manual in compliance with 4.18.1;
- installation manual in compliance with 4.18.2; and
- evidence of compliance with IEC 60945 for all parts of the INS (see 4.1).

Check that the manufacturer's documentation (installation manual) contains detailed information about the available interfaces and thereby supported functions.

Check that the manufacturer's documentation contains information about each part of the INS. The manufacturer shall declare which parts form the INS.

Check documentation that each part of the INS complies with the applicable requirements adopted by IMO, including the requirements of IMO resolution MSC 86(70) Annex 3.

Check that the manufacturer provides sufficient information about which parts of the INS can execute multiple operations. Check that these multiple operations are in compliance with requirements specified for each individual function they can control, monitor or perform.

8.5 Compliance tests

8.5.1 Added value of INS

(see 4.1.2)

Check the manufacturer's documentation with respect to "added value" of functions and operation and how this is achieved.

8.5.2 Three INS categories

(see 4.1.6)

Check that the manufacturer's documentation contains information indicating which INS category applies to the EUT.

8.5.3 Safety of navigation support

(see 4.1.12)

Check that information from all connected sensors is displayed permanently or on demand as required by 4.10 (evaluation of different sensors of different types for example on a sensor page).

Check that the EUT provides detection of potential dangers, and upon detection, announces appropriate warnings/alarms. Check that the requirements of 4.13 are met.

8.5.4 Consideration of human factors

(see 4.1.13)

Check that the requirements of IEC 60945, 4.2.1.5 (Screen display and indications) are fulfilled.

Check the consistent use of terms and their definitions, abbreviations, colours and symbols, and other presentation characteristics to ensure that navigation-related information is presented to the mariner with a consistent human-machine interface (HMI).

8.5.5 INS basic functions

(see 4.2)

8.5.5.1 Combination, processing and evaluation

(see 4.2.1)

Check that the EUT combines, processes and evaluates data from all connected sensors for obtaining at least the following information:

- speed over ground and through water;
- heading;
- position;
- depth; and
- time

for the purposes of the integrity evaluation.

8.5.5.2 Mode and situation awareness

(see 4.2.2)

Check that the EUT supports mode and situation awareness by displaying:

- validated data, where possible**,** of all connected navigation sensors;
- the specified INS information and its status, including modes of operation and display where available. (mode of operation, e.g. heading or track control);
- changes to this information and appropriate alarms and indications, as required by the INS category;
- hazards in accordance with the individual standards (e.g. ENC data, radar).

8.5.6 Multifunction display

(see 4.3.1)

Check that where information or controls are presented on a multifunction display unit they are redundantly available.

Check that the failure of a single multifunction display does not result in the loss of a function mandated by the carriage requirements of SOLAS.

8.5.7 Interfacing and data exchange

(see 4.4)

8.5.7.1 Interfacing stand-alone equipment

(see 4.4.1)

Tests may be performed using a simulator or at sea.

Input digital signals into the EUT to emulate the connected sensors and stand-alone equipment as follows:

- signals carrying positional data conforming to the IEC 61162 series and the appropriate EPFS standard;
- signals carrying heading information conforming to IMO resolutions A.424(XI) and A.821(19); any digital output shall conform to the IEC 61162 series if available;
- signals carrying speed information conforming to IMO resolution A.824(19); any digital output shall conform to the IEC 61162 series;
- signals carrying depth information conforming to IMO resolution A.224(VII); any digital output shall conform to the IEC 61162 series;
- signals carrying AIS information conforming to the IEC 61162 series and the appropriate standard for Universal Automatic Identification System (AIS).

Signals may also be provided to represent radar returns as follows:

- simulated ARPA signals, provided by the supplier, conforming to IMO resolution A.823(19); any digital output shall conform to the IEC 61162 series;
- simulated or real radar signals in accordance with annex 4 to IMO resolution MSC.64(67) provided by the supplier.

Test the digital inputs and outputs of the system interfaces according to the tests described in the relevant standards.

Check correct operation of the interfaces. Where the datum reference sentence (DTM) is received in accordance with IEC 61162-1 check that it is processed accordingly.

8.5.7.2 Plausibility checks

(see 4.4.2)

Check that the EUT carried out checks for plausible magnitudes of values for data received or derived data that is used or distributed by the EUT.

Check that data failing the plausibility checks are not used by the EUT and do not affect functions not dependent on these data as defined in Table 1.

8.5.7.3 Validity checks

(see 4.4.3)

Check that the data received by the EUT take the validity marking of the sensor into account.

Check that the data distributed by the EUT are marked with validity indication.

Check that data failing the validity checks are not be used by the INS and do not affect functions not dependent on these data as defined in Table 1.

8.5.7.4 Integrity of data exchange

(see 4.4.4)

Check the integrity of the data exchange by checking the consistency of data within each part of the INS. For example:

- sensor data;
- routes;
- data bases, for example chart data base, user chart, navigation lines;
- dynamic ship parameter, for example turning radiuses, rate of turn;
- static ship parameter, for example dimensions.

NOTE This can be done by visual means or other comparative methods.

8.5.7.5 Data output

(see 4.4.5)

Check that details of the available interfaces are included in the manufacturers' documentation.

Check that data output from the INS complies with IEC 61162 series as applicable and that where an alternative interface is used details are included in the installation manual.

Where interfaces with IEC 61162-1 sentences are used:

a) check that positional information is transmitted in the WGS84 datum and includes the datum reference sentence (DTM) in accordance with IEC 61162-1;
b) check that system data and other data checked for integrity, modified or generated by the INS are transmitted with the talker identifier "IN"; or otherwise the talker identifier of the source is used.

8.5.8 Accuracy and performance

(see 4.5)

Check that the accuracy and other properties (for example update rate, range, resolution) of information meet the requirements of the resolutions adopted by IMO for the individual navigational aids connected to or forming part of the system.

Check that the INS does not degrade the accuracy of the data provided by the sensors.

8.5.9 Consistent common reference system (CCRS)

(see 4.6)

8.5.9.1 General

Check that the manufacturer has demonstrated that a CCRS is used and that information from the CCRS is:

a) referenced to same place and time as defined in 4.6.2;
b) compensated for latency as defined in 4.6.1;
c) checked for validity;
d) checked for plausibility.

Check that data is presented with a warning when it is not possible to perform the calculations required in a) and b). Check that data is marked as invalid if the tests c) or d) fail in accordance with Table 1.

Check that the operating manual provides sufficient information for operation of the CCRS.

Check that the CCRS is provided with documented set-up facilities.

Check by visual inspection that all parts of the INS are provided with the same type of data from the same source.

When ground velocity is used check that its components are derived from the same source.

Check that any presented data which is not part of the CCRS is clearly identified as such.

8.5.9.2 Latency of system data

(see 4.6.1)

Check by comparison of the data output from the sensor and data input for the function (for example display of data or input for AIS transponder) that the latency for each data is as required for the function. For example:

- by comparison of the photo from the display unit of sensor and the photo from the INS display at the same time;
- by display of both sets of data at one display, for example if both data sets are available in serial format according IEC 61162-1.

Check that data requirements of the individual parts (MSC 86(70), 4.1.13) and their relevant International Standards are fulfilled.

8.5.9.3 Consistent common reference point

(see 4.6.2)

Check that a consistent common reference point is provided and includes facilities to enable set-up and offset adjustment. Check that the installation manual includes a description of these adjustments.

Check that it is possible to adjust the location offsets from all connected sensors providing spatially related data. Check that the offsets can be stored and recalled.

Check that set-up and offset adjustments are only available through a secure access, for example password or “dongle”.

Where more than one reference location is provided, check that they are clearly indicated or distinctively obvious.

Check that the selection of an alternative reference point does not affect the integrity monitoring process.

Check that the manufacturer has demonstrated that a consistent common reference point is used throughout the system.

8.5.10 Integrity monitoring

(see 4.7)

8.5.10.1 General

Throughout the tests of the integrity monitoring provided by the INS system, a single point of failure shall be used.

a) Check the manufacturer's documentation for details regarding essential information, including, as a minimum, position, speed, heading and time.

b) Simulate appropriate error-free (undisturbed) data input and observe that essential information displayed has a valid integrity indication. Check that essential information with valid integrity is used by the INS functions. Simulate the input of data specified above with error and offset greater than the threshold in use and observe that the integrity status changes and the INS reacts accordingly.

c) Check that the INS provides for the manual or automatic selection of sources for integrity monitoring as specified in the manufacturer's documentation. Check that a clear indication of the sources of data selected for integrity monitoring is available on request. Check that the INS indicates if RAIM is used for integrity monitoring.

d) Check that the INS can accept multiple sensor inputs for the following data:

- ship's heading;
- speed through water,
- EPFS position;
- time (e.g. from GNSS);
- velocity over ground (e.g. from EPFS).

8.5.10.2 Verification of position integrity

(see 4.7.1.1)

a) Simulate error-free data necessary for the following checks and observe that the INS performs integrity monitoring with all available data as follows:

- comparison with a second EPFS;
- processing an output of the RAIM GNSS function;
- dead reckoning using the ship's heading and speed measuring device as input data to detect position jumps.

Check that the INS operates normally and provides an indication of valid integrity for position.

b) Simulate errors (disturbances, jumps) exceeding the thresholds in use for the EPFS selected for system data.

Check that the integrity monitoring process detects jumps and errors of EPFS selected for system data exceeding thresholds in use and integrity of position is marked as failed and the system reacts appropriately.

c) Set up the system so that a single means of integrity monitoring is in use (e.g. a second EPFS only, or use of RAIM only). Simulate errors (disturbances, jumps) in the means in use as the sole source for integrity monitoring.

Check that position integrity is marked as failed and the system reacts appropriately.

d) Set up the system so that two or more means of position integrity checks are being applied (e.g. more than two EPFS, or a primary EPFS with RAIM and a second EPFS). Simulate errors (disturbance, jumps) exceeding the threshold in use on each of the means of integrity check individually (other than that selected for system data).

Check that the position integrity is marked as passed and the system reacts appropriately.

8.5.10.3 Verification of heading integrity

(see 4.7.1.2)

a) Simulate error-free data necessary for the following tests and observe that the INS performs integrity monitoring as follows:

- comparison with a second heading sensor;
- comparison with a course over ground sensor.

Check that the INS operates normally with indication of valid integrity for heading.

b) Simulate errors (disturbances, jumps) exceeding the thresholds in use for the heading sensor selected for system data.

Check that the integrity of heading is marked as failed and that the system reacts appropriately.

c) Set up the system so that a single means of integrity monitoring is in use (e.g. a second heading sensor). Simulate errors (disturbances, jumps) in the means in use as the sole source for integrity monitoring. Repeat the test using a COG sensor in place of the second heading sensor.

Check that the heading integrity is marked as failed and the system reacts appropriately.

8.5.10.4 Verification of speed through water integrity

(see 4.7.1.3)

a) Simulate error-free data necessary for the following tests and observe that the INS performs integrity monitoring as follows:

- comparison with a second speed through water sensor;
- comparison with a speed over ground sensor.

Check that the INS operates normally with indication of valid integrity for speed through water.

b) Simulate errors (disturbances, jumps) exceeding the thresholds in use for the speed through the water sensor selected for system data.

Check that the integrity of speed through the water is marked as failed and that the system reacts appropriately.

c) Set up the system so that a single means of integrity monitoring is in use (e.g. a second speed through the water sensor). Simulate errors (disturbances, jumps) in the means in use as the sole source for integrity monitoring. Repeat the above using a speed over the ground sensor as the sole source for integrity monitoring.

Check that the speed through the water integrity is marked as failed and the system reacts appropriately.

8.5.10.5 Verification of velocity over ground integrity

(see 4.7.1.4)

a) Simulate error-free data necessary for the following tests and observe that the INS performs integrity monitoring as follows:

- comparison with a second velocity over ground sensor;
- comparison with a speed through water sensor, for example EM-Log;
- comparison with ground velocity from an EPFS.

Check that the INS operates normally with indication of valid integrity for speed over ground.

b) Simulate errors (disturbances, jumps) exceeding the thresholds in use for the speed over ground sensor selected for system data.

Check that the integrity of speed over the ground is marked as failed and that the system reacts appropriately.

c) Set up the system so that a single means of integrity monitoring is in use (e.g. a second speed over the ground sensor). Simulate errors (disturbances, jumps) in the means in use as the sole source for integrity monitoring. Repeat the test using:

- a speed through the water sensor;
- an EPFS sensor.

Check that the speed over the ground integrity is marked as failed and the system reacts appropriately.

8.5.10.6 Verification of time integrity

(see 4.7.1.5)

a) Simulate error-free external time data. Check that the INS operates normally with indication of valid integrity for time.

b) Simulate errors (disturbances, jumps) exceeding the thresholds in use for external time sources (other than that selected for system data). Check that the integrity monitoring process detects errors exceeding thresholds in use and marks the time integrity as failed and that the system reacts appropriately.

8.5.10.7 Verification of depth integrity

(see 4.7.1.6)

a) Simulate error-free data necessary for the following tests and observe that the INS performs integrity monitoring as follows:

- comparison with a second depth sensor;
- comparison with electronic chart data.

Check that the INS operates normally with indication of valid integrity for depth.

b) Simulate errors (disturbance, jumps) exceeding thresholds in use for depth sensor selected for system data.

Check that the integrity of depth is marked as failed and that the system reacts appropriately.

c) Simulate errors (disturbance, jumps) exceeding the thresholds in use for alternative depth sensor (other than that selected for system data) selected for integrity monitoring.

Check that the depth integrity is marked as failed.

d) Simulate a mismatch of sensor depth data with electronic vector chart data.

Check that the depth integrity is marked as failed.

8.5.10.8 Integrity monitoring thresholds

(see 4.7.2)

Check from the manufacturer’s documentation that the threshold for integrity calculations is based on the specified or expected (where not specified) sensor accuracy at a probability of 95 %.

Check that thresholds for integrity monitoring can be displayed on request.

8.5.10.9 Adaptation of integrity monitoring thresholds

(see 4.7.2.1)

Check that adaptable thresholds for integrity monitoring are limited to maximum values as stated in the manufacturer's documentation.

8.5.11 Marking of data

(see 4.8)

8.5.11.1 Marking of data after integrity check

(see 4.8.1)

NOTE These tests may be combined with and verified during execution of tests in 8.5.10.1 to 8.5.10.7.

a) Check that essential information used in INS is marked with the result of its integrity monitoring. Check that functions of the INS use data integrity information as applicable (for example data with integrity check failed cannot be used for automatic control functions).

b) Simulate the situation when integrity of essential information is doubtful and check that this essential information is clearly marked as doubtful and not used for automatic control functions.

8.5.11.2 Marking of doubtful data

(see 4.8.2)

Simulate situations as per Table 1 and check that the INS performs marking of data and provides alarms and indications as specified.

8.5.12 Generation of alarms and warnings

(see 4.9)

8.5.12.1 Indication of invalid information

(see 4.9.1)

Set invalid status for the simulated input data used by the INS to generate essential information or for control function and check that alarm is generated. (see also test for delayed alarm, 8.5.15.2)

Repeat the test for corrupted and lost data input.

Set the invalid status for the simulated input data used by the INS to generate non-essential information. Check that a warning is generated.

8.5.12.2 Impossible integrity verification

(see 4.9.2)

Simulate the situation when integrity monitoring of essential information can no longer be performed (for example disconnect the second sensor). Check that information is marked as doubtful and a warning is generated.

In case of INS(C) repeat the test for active control mode and check that an alarm is generated.

8.5.13 The INS display

8.5.13.1 Display of available information

(see 4.10.1)

Check that the INS can display information in accordance with its INS category in compliance with this and other International Standards.

Check that the presentation of the information is as described in the operators manual.

8.5.13.2 Display of essential information

(see 4.10.2)

Check that the following information is displayed simultaneously upon a simple operator command:

- essential information as required by the current INS functions in use;
- depth of water under the keel (in case of INS(B) and where available);
- display mode (where not distinctively obvious);
- mode of operation (where not distinctively obvious).

Check that supplementary information related to the essential information is readily accessible by easy means.

8.5.13.3 Content of information for display

(see 4.10.3)

Check that sensor information and navigational information are displayed together with the indication of their:

- source; (sensor data, e.g. GYR 1, GYR 2, GPS 1, GPS 2, LORAN, EM log, Doppler log, radar 1, radar 2, etc.);
- result of calculation or manual input;
- unit of measurement;
- status, including mode.

8.5.13.4 Display of additional information

(see 4.10.4)

Check that if additional information is displayed the system state is observable and essential data are displayed.

Check that any additional navigation information that is displayed does not mask, obscure or degrade essential information required for display by this standard, for example a help window superimposed on the display, or required for the operation of the current INS functions in use.

8.5.13.5 Display of sensor output data

(see 4.10.5)

Check that sensor output information can be displayed on demand. Check that display of sensor output information is clearly marked as such.

Check that sensor output information is displayed together with an indication of

- its source (sensor data, e.g. GYR 1, GYR 2, GPS 1, GPS 2, LORAN, EM log, Doppler log, radar 1, radar 2, etc.);
- whether it is a result of calculation or manual input;
- its unit of measurement;
- its status, including mode.

8.5.13.6 Configuration display

(see 4.11)

Check that the complete INS configuration can be presented on request and includes information about all installed subsystems and connected sensors.

Check that the available INS configuration can be presented on request and includes information about all subsystems ready for use and connected sensors providing the INS with data.

Check that the INS configuration in use can be presented on request and includes information about all subsystems and sensors currently in use.

Disconnect one of the sensors and check that configuration display reflects the changes.

NOTE The configuration may be presented either graphically or as a list.

8.5.14 Malfunctions

8.5.14.1 Failure effects and independent functionality

(see 4.12.1.1)

a) Independently disable parts of the INS and check by a performance check (see 3.1.34) that only those functions dependent on the disabled part are affected and that the individual parts can be independently operated.

b) Independently interrupt data exchange between parts of the INS and check by a performance check that this does not affect independent parts.

8.5.14.2 Malfunction of additional facilities

(see 4.12.1.2)

Identify the EUT interfaces providing facilities which are additional to this standard. Generate malfunctions related to additional facilities on identified interfaces.

Conduct a performance check to check that the performance of EUT is not degraded below the requirements of this standard as far as is reasonably practicable.

8.5.14.3 Failure of one part

(see 4.12.1.3)

a) Independently generate failures of parts that, according to the manufacturer’s declaration, require immediate operator attention and check that the failure is indicated by alarm.

b) Independently generate other failures of parts and check that at least a warning is given.

8.5.14.4 Automatic response to malfunctions

(see 4.12.1.4)

Independently generate the malfunctions declared by the manufacturer and check that the reaction of the EUT is in compliance with the relevant equipment standards and the manufacturer's declaration.

8.5.14.5 Fall-back arrangements

(see 4.12.2)

Disable the primary/ selected positioning source. Check that position is provided by a fall-back arrangement.

Re-enable the positioning source, disable the primary/ selected speed source. Check that speed is provided by a fall-back arrangement.

Re-enable the speed source, disable the primary/ selected heading source. Check that heading is provided by a fall-back arrangement.

Re-enable the heading source, disable the primary/ selected source providing time. Check that time is provided by a fall-back arrangement.

Re-enable the source providing time, independently disable other functions of the INS. Check that the disabled function remains available through fall-back arrangements as per individual equipment standards, as applicable.

8.5.14.6 Restored operation

(see 4.12.2.2)

Cause the INS to change to fall-back mode by causing failure conditions other than by interrupting power or by intentional shut down. Remove the failure conditions.

Check that the normal operational mode cannot be resumed without operator invention.

8.5.15 INS alarm management

(see 4.13)

Check that an alarm management system is provided and that the number of alarms is kept to a minimum.

Check by assessment of documentation or system check that any centralised ship alarm management system intended to take over or perform any functions of the INS alarm management system complies with relevant requirements of this standard.

Check that the alarm management system is capable of replacing the announcement function of navigation equipment intended for connection to the INS. Check that the announcement function meets the relevant requirements for those individual navigation equipments.

Check that the installation manual of the INS includes guidance showing the physical layout of the INS alarm management system. Check that this layout supports availability of INS alarms and indications of their sources at the navigating and manoeuvring workstation.

8.5.15.1 Generation of alarms, warnings and indications

(see 4.13.2)

Check, by an appropriate selection and at least all alarms, warnings and indications required by this standard (see Annex D), that alarms, warnings and indications announced by the INS comply with 4.13.2.

8.5.15.2 Alarm delay

(see 4.13.2.1)

Check that the maximum delay for any alarm cannot be set to more than 30 s.

Where alarms are delayed check that at least an indication is generated not later than 5 s after the alarm condition occurs.

Where an alarm delay facility is provided check that guidance is given in the documentation for setting-up the delay values

8.5.15.3 Alarm, warning and indication announcement

(see 4.13.3)

Check compliance with Table 2.

8.5.15.4 Display of alarms, warnings and indications

(see 4.13.4)

Check that alarms, warnings and indications are presented in accordance with relevant standards on presentation, and that:

- alarm reasons and the resulting functional restrictions can be easily understood;
- alarms, warnings and indications are self-explanatory.

8.5.15.5 Back-up officer alarm

(see 4.13.5)

Check that the INS provides an interface for a back-up officer alarm, at least for those alarms required by the individual standards.

Check that this interface is activated when an alarm has not been acknowledged within 30 s. Check that the installation documentation includes information which shows that the backup officer alarm acknowledgement can only be carried out on the ship’s bridge.

8.5.15.6 Standby alarm mode

(see 4.13.6)

If a standby alarm mode is provided by the INS, check that:

- a clear indication is presented whenever such a mode is active;
- activation and deactivation requires operator action;
- activation requires confirmation from the operator; and
- automatic control functions cannot be activated in the standby alarm mode.

Check that the installation documentation includes information which shows that implementation and cancellation of the standby alarm mode are only be possible from a location on the ships bridge.

8.5.15.7 Alarm limit consistency

(see 4.13.7)

Identify all INS operator interfaces on which alarm settings are displayed. Check that the alarm settings are consistent on all of the interfaces identified.

Identify all INS operator interfaces that allow manual adjustment of alarm settings. Change the settings for a representative selection of alarms for one of the interfaces identified. Check that either the settings are automatically changed and so remain consistent on all INS displays on which the alarm settings are displayed or that indication is given by the INS, that the alarm settings are not consistent.

Repeat the change of the alarms on each of the other interfaces which allow manipulation of the alarm settings and verify similar results.

8.5.16 Human machine interface (HMI)

8.5.16.1 Information display

(see 4.14.1)

Identify all parts of the HMI displaying INS information.

For display interfaces associated with individual functions for which performance standards exist, check that the documentation provides evidence of compliance with IEC 60945 for each individual function.

For display interfaces associated with individual functions for which no performance standard exists, tests are to be carried out in accordance with the requirements of IEC 60945 and other International Standards which relate to the display of information in order to demonstrate compliance with the requirements for all interfaces associated with each individual function.

For all display interfaces, irrespective of associated INS function, tests are to be carried out in accordance with the requirements of IEC 60945 and other International Standards relating to consistency of presentation, in order to demonstrate that the display of information associated with each of the interfaces is consistent between all functions provided by the INS.

8.5.16.2 Manual inputs

(see 4.14.2)

Check that manual user inputs are easy to execute and comply at least with the requirements of IEC 60945.

8.5.16.3 Input errors

(see 4.14.3)

Check that the INS requests confirmation and provides user guidance before accepting user inputs that may cause unintended results, and which may lead to excessive sudden manoeuvres or to loss of data.

8.5.16.4 Physical layout of operational controls

(see 4.14.4)

Check that the installation manual of the INS includes guidance showing the physical layout of the operational controls. Check that this layout supports easy operation of the basic functions.

8.5.17 Power supply tests

8.5.17.1 Orderly shut down

(see 4.15.3)

Shut down the EUT according to manufactures declaration. Turn on the EUT. Observe the initial functions and their availability. Observe the operational modes, display modes and control modes, and the alarms and warnings caused by missing functions or data triggered by the turn on procedure.

Check that the EUT default state is compliant with the manufacturers declaration.

8.5.17.2 Recovery time

(see 4.15.4.1)

Interrupt power of the EUT until all subsystems and functions are shut down. Restore the power supply to the EUT. Measure recovery time of the individual subsystems or functions.

Check that the recovery time of the individual subsystems or functions is not greater than that specified in relevant standards for the individual subsystems or functions.

8.5.17.3 Functions after recovery

(see 4.15.4.2)

Record the configuration, mode, automated operation and automatic functions in use. Interrupt power of the EUT until all subsystems and functions are shut down.

Restore power supply to the EUT. Record the configuration, mode, automated operation and automatic functions in use.

Check that the configuration, mode and automated operation (as far as practical) are maintained. Check that safety related automatic functions are only restored upon confirmation by the operator.

8.5.18 INS(B) and (C) tests

8.5.18.1 INS(B) – Route planning and route monitoring

(see 6.2)

Identify parts providing route planning and route monitoring functions. Where no evidence of approval of these parts to IEC 61174 is available, conduct tests according to the relevant requirements specified in IEC 61174 and check that all identified parts are compliant with the relevant requirements of IEC 61174.

8.5.18.2 INS(C) – Heading or track control system

(see 7.1)

Identify parts providing heading control functions. Identify parts providing track or track and speed control functions. Check that all identified parts for heading control are approved according to ISO 11674 and all identified parts for track or track and speed control are approved according to IEC 62065.

8.5.19 INS(C) – Operator control and display functions

(see 7.2)

Identify the workstation capable of accepting control commands. In case of multiple workstations, enter control commands at each workstation in turn. Transfer control between each of the workstations capable of taking control.

Check that it is clear which workstations do not accept control commands. Check that only one of the workstations accepts control commands at a time. Check that it is not possible to prevent the transfer of control between workstations.

8.5.20 INS(C) – Reversionary mode

(see 7.3)

Operate the controls for bypassing or overriding automatic heading, speed or track control in different operational modes and failure modes. Check that in all cases bypassing the automatic mode is possible by a single operator action.

Cause automatic heading, speed or track control to switch to a reversionary mode by causing failure conditions. Remove the failure conditions. Check that an appropriate warning message is given prior to resumption of the original automatic mode. Check that the original automatic mode cannot be resumed without operator invention.

Annex A
(normative)

IMO Resolution MSC 86(70) Annex 3
(adopted on 8 December 1998)
Recommendation on performance standards for an integrated navigation system (INS)

1 SCOPE

1.1 The purpose of an integrated navigation system (INS) is to provide 'added value' to the functions and information needed by the officer in charge of the navigational watch (00W) to plan, monitor or control the progress of the ship.

1.2 The INS supports mode and situation awareness.

1.3 The INS supports safety of navigation by evaluating inputs from several independent and different sensors, combining them to provide information giving timely warnings of potential dangers and degradation of integrity of this information. Integrity monitoring is an intrinsic function of the INS.

1.4 The INS aims to ensure that, by taking human factors into consideration, the workload is kept within the capacity of the 00W in order to enhance safe and expeditious navigation and to complement the mariner's capabilities, while at the same time to compensate for their limitations.

1.5 The function of passage execution in an Integrated Bridge System (IBS), as defined by the Organization* may be performed by an INS.

2 APPLICATION

2.1 These performance standards are applicable to any combination of navigational aids that provides functions beyond the general intent defined in the respective performance standards adopted by the Organization for individual equipment.

2.2 The purpose of these performance standards is to support the proper and safe integration of navigational equipment and information.

2.3 These performance standards define three categories of INS:

.1 INS(A) for systems that provide the minimum functional requirements of the INS including a consistent common reference system;
.2 INS(B) for systems that, in addition to the functional requirements of INS(A), provide the information needed for decision support in avoiding hazards; and
.3 INS(C) for systems that, in addition to the functional requirements of INS(B), provide the automatic control functions of heading, track or speed.

3 DEFINITIONS

For the purpose of these standards the following definitions apply.

3.1 **Automatic control system –** A control system that may include a heading, track or speed control system.

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* Resolution MSC.64(67), Annex 1 – Recommendation on performance standards for Integrated Bridge Systems

3.2 **Consistent common reference system –** A sub-system of an INS for acquisition, processing, storage and distribution of data and information providing identical and obligatory reference to sub-systems within an INS.

3.3 **Integrated navigation system –** An INS is a combination of systems that are interconnected to increase safe and efficient navigation by suitably qualified personnel.

3.4 **Integrity –** Ability of the system to provide the user with information within the specified accuracy in a timely, complete and unambiguous manner, and alarms and indications within a specified time when the system should be used with caution or not at all.

3.5 **Multifunction display –** A single visual display unit that can present, either simultaneously or through a series of selectable pages, information from more than one operation of a system.

3.6 **Sensor** – A navigational aid, with or without its own display and control as appropriate, automatically providing information to the INS.

4 OPERATIONAL REQUIREMENTS

4.1 Functionality

General

4.1.1 In addition to meeting the relevant requirements of resolution A.694(17)*, the INS should comply with the requirements of these performance standards.

4.1.2 Each part of the INS should comply with all applicable requirements adopted by the Organization, including the requirements of these performance standards. Parts executing multiple operations should meet the requirements specified for each individual function they can control, monitor or perform.

4.1.3 When functions of equipment connected to the INS provide facilities in addition to these performance standards, the operation and, as far as is reasonably practicable, the malfunction of such additional facilities should not degrade the performance of the INS below the requirements of these standards.

4.1.4 A failure of one part should not affect other parts except for those functions directly dependent upon the information from the defective part.

Basic functions

4.1.5 An INS should combine, process and evaluate data from all sensors in use. The integrity of data from different sensors should be evaluated prior to distribution.

4.1.6 An INS should ensure that the different types of information are distributed to the relevant parts of the system, applying a 'consistent common reference system' for all types of information.

4.1.7 The INS(A) should as a minimum provide the information of position, speed, heading and time, each clearly marked with an indication of integrity.

4.1.8 The INS(B) should be able to automatically, continually and graphically indicate the ship's position, speed and heading and, where available, depth in relation to the planned route as well as to known and detected hazards.

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* See also IEC 60945.

4.1.9 The INS(C) should, in addition, provide means to automatically control heading, track or speed and monitor the performance and status of these controls.

Integrity monitoring

4.1.10 The integrity of information should be verified by comparison of the data derived independently from two or more sources if available.

4.1.11 The integrity should be verified before essential information is displayed or used. Information with doubtful integrity should be clearly marked by the INS and should not be used for automatic control systems.

Data exchange

4.1.12 Stand-alone equipment for which performance standards adopted by the Organization exist, when connected to the INS, should comply with the applicable international standards* for data exchange and interfacing.

4.1.13 Data latency should be consistent with the data requirements of the individual parts.

4.1.14 The integrity of data exchange within the INS should be ensured.

4.1.15 A failure of data exchange should not affect any independent functionality.

Integration

4.1.16 The INS should provide functional integration meeting the following requirements:
.1 where a display or control is presented on a multifunction display unit then these should be redundantly available; and
.2 validity* of the data should be provided for each part to be integrated.

Configuration control

4.1.17 It should be possible to display the complete system configuration, the available configuration and the configuration in use.

4.2 Information and accuracy

Display of information

4.2.1 The INS should be able to display the information available in accordance with paragraphs 4.1.7, 4.1.8 and 4.1.9 as applicable.

4.2.2 The INS should be capable of displaying output data available from the sensors.

4.2.3 The information should be displayed together with the indication of its source (sensor data, result of calculation or manual input), unit of measurement and status, including mode (see Integrity monitoring).

Accuracy

4.2.4 As a minimum, the accuracy of information should meet the requirements of the resolutions** adopted by the Organization. Additionally the INS should not degrade the accuracy of the data provided by the sensors.

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* IEC 61162

** Resolutions A.529(13) and A.815(19)

4.3 Malfunctions, alarms and indications

Fail safe operation

4.3.1 The system's automatic response to malfunctions should result in the safest of any other configuration accompanied by clear indications and alarms.

Reversionary mode

4.3.2 The INS should allow simple and effective operator action to override or by-pass any automated functions. The INS should resume automatic functions only after an appropriate message and intended operator action, considering all necessary starting conditions.

Alarm management

4.3.3 An alarm management system should be provided.

4.3.4 The INS alarm management system, as a minimum, should comply with the requirements of the Organization.*

4.3.5 The number of alarms should be kept as low as possible by providing indications for information of lower importance.

4.3.6 Alarms should be displayed so that the alarm reason and the resulting functional restrictions can be easily understood. Indications should be self-explanatory.

5 ERGONOMIC CRITERIA

5.1 Cognitive ergonomics

5.1.1 Integrated display and control functions should adopt a consistent human machine interface (HMI) philosophy and implementation.

5.1.2 The HMI should be so designed that the provided information is clearly understood using a consistent presentation style.

5.1.3 The HMI should be so designed that the requested manual inputs can be easily executed.

5.1.4 For manual inputs that may cause unintended results, the INS should request confirmation before acceptance, thus providing a plausibility check.

5.2 Physical ergonomics

Controls and displays

5.2.1 Particular consideration should be given to:

- symbols;
- controls; and
- layout.

Operational controls

5.2.2 The INS should be designed and implemented so that the operator easily operates basic functions from INS workstations.

Presentation of information

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* Resolution A.830(19)

5.2.3 Continuously displayed information should be optimised and should include position, speed, heading and time. Supplementary information should be readily accessible.

6 DESIGN AND INSTALLATION

General

6.1 The INS should meet the relevant requirements of resolution A.694(17) and appropriate international standards*.

Failure analysis

6.2 A failure analysis** should be performed and documented for the installed configuration of the INS which includes all parts connected to or integrated into the system, including devices for manual override of automatic functions and their locations on the bridge.

Installation requirements

6.3 The INS should be installed so that it can meet the requirements of the relevant International Standards.***

Power supply requirements

6.4 Power supply requirements applying to parts of the INS as a result of other IMO requirements should remain applicable.

6.5 The INS should be supplied:

.1 from both the main and the emergency source of electrical power with automated changeover through a local distribution board with provision to preclude inadvertent shutdown; and

.2 from a transitional source of electrical power for a duration of not less than 45 s.

Power interruptions and shutdown

6.6 After a power interruption full functionality of the INS should be available after recovery of all subsystems. The INS should not increase the recovery time of individual subsystem functions after power restoration.

6.7 If subjected to a power interruption the INS should, upon restoration of power, maintain the configuration in use and continue automated operation, as far as practicable. Safety related automatic functions, should only be restored upon confirmation by the operator.

7 INTERFACING

Interfacing to, and from, the INS should comply with international standards****, as appropriate.

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* IEC 60945

** See also IEC 61508

*** IEC 92-101 and 533

**** IEC 61162

8 FALL-BACK ARRANGEMENTS

8.1 The INS should, after a failure, support the availability of essential information through the use of appropriate fall-back arrangements.

8.2 Normal operation, after use of a fall-back arrangement, should only be restored upon confirmation by the operator.

Annex B
(informative)

Data flow diagram/consistent common reference system (CCRS)

This information is intended to clarify the minimum requirements for data flow through the parts of the INS carrying out sensor data pre-processing, integrity monitoring, consistent common reference and system data distribution. The management of known data and parameters are included.

The data flow diagram includes processes to determine the validity and plausibility of all input data, to determine their integrity and to provide system data for distribution. For essential information the sensor data pre-processing ensures that the same type of data is from the same source, and it ensures consistency of any distributed or displayed information.

The following numbers relate to those within the circles in Figure B.1.

1. The INS receives sensor data from various sources.
   - The raw data from a sensor may or may not be marked with a validity flag.
   - The raw data from a sensor may or may not be marked with an integrity status flag and complemented with expected error data (e.g. from RAIM or equivalent monitoring function).

2. The data received from sensors may be related to an individual given point of measurement (e.g. antenna position, place of installation) and may be related to the individual time scale within each sensor. In such cases, data synchronisation, spatial correction and selection may be necessary as additional preconditioning.

3. Known data and parameter (e.g. knowledge of measurement of the ship's hull, reference dimensioning of antenna positions, threshold values to be used for integrity monitoring, maximum ROT of the vessel, ...) may be centrally managed for common use in sensor data pre-processing functions and may be distributed as a subset of system data.

4. Data from consistent common reference may be used for integrity monitoring to fill possible gaps in availability of data originally received from sensors and to provide appropriate consistent common reference and checked status.

Optional:

5. A fast access data channel may be applicable to those functions within an INS and/or to that external equipment where data without any time lag are required. In such cases, dedicated sources may be connected in parallel to sensor data pre-processing and to a fast access data channel. With simultaneous consideration of the following preconditions a fast access data channel can be used:
   - an error correction function is supplied externally **and**
   - a spatial correction for that type of data is not required **and**
   - the integrity monitoring for data used in the fast access data channel is provided simultaneously by the integrity monitoring function within the INS **and**
   - the data selection complies with the requirements of the CCRS **and**
   - the fast access data channel is fed through system data distribution **and**
   - data transferred through the fast access data channel are complemented with the integrity status and the expected error as a result from integrity monitoring within the INS.

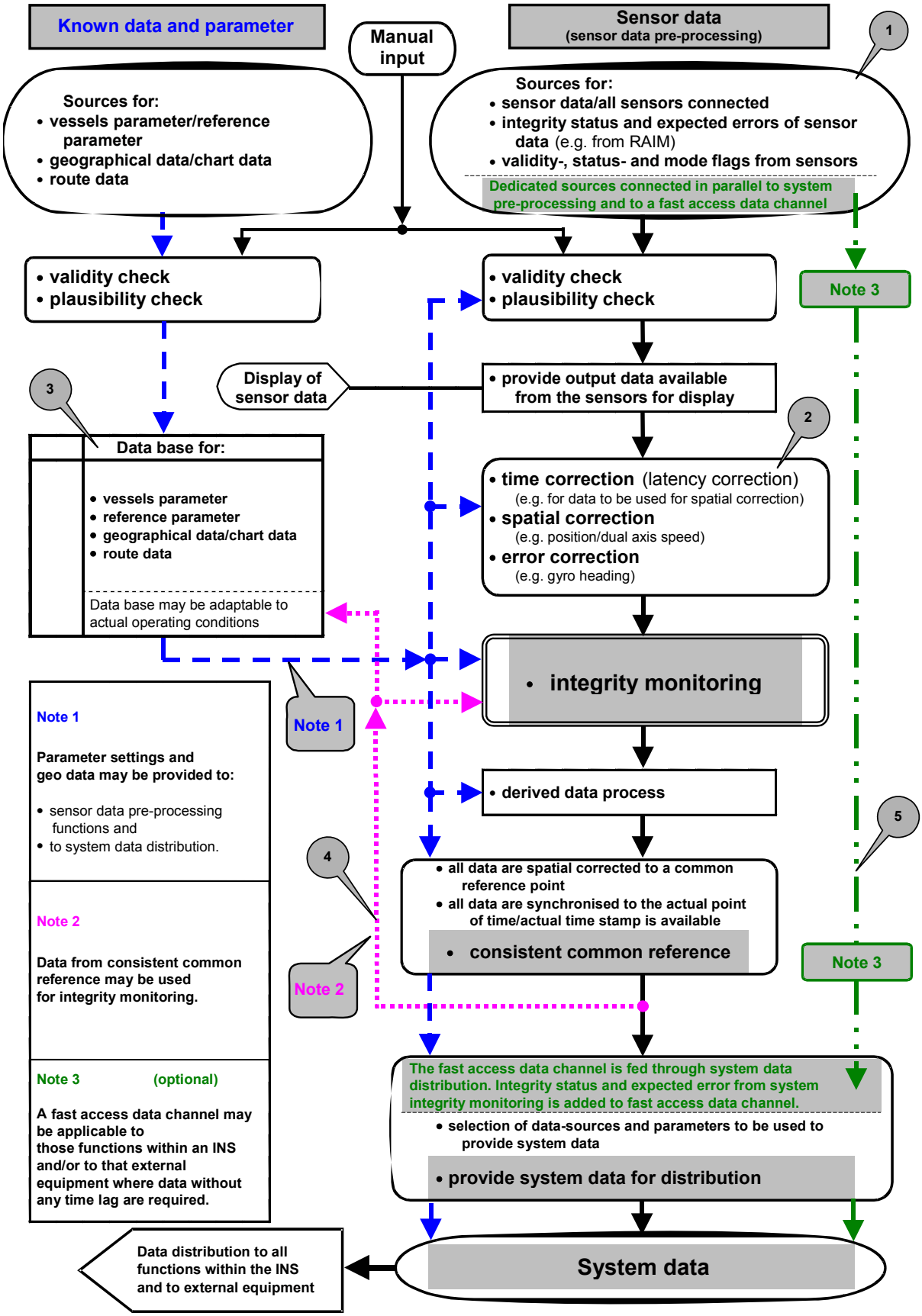

Figure B.1 – Data flow diagram/consistent common reference system (CCRS)

Annex C
(normative)

IEC 61162 output interfaces

C.1 IEC 61162 series interfaces

The INS shall be capable of transmitting system data using the IEC 61162 series sentences specified in the table below:

Table C.1 – IEC 61162 sentences transmitted by the INS

Mnemonic	Name	Comment
ACK	Acknowledge alarm	Alternative means of acknowledging an alarm on external equipment may be provided.
ALR	Set alarm state	Current alarm state of the INS
DPT	Depth	INS(B) and INS(C) only
DTM	Datum reference	
GLL	Geographic position – latitude/longitude	
HDT	Heading true	
OSD	Own ship data	
ZDA	Time and date	

Annex D
(informative)

Alarm and warning conditions

Table D.1 – Alarm and warning conditions

Subclause	Announcement	Condition
4.6	Warning	Data not referenced to same place and time
4.6	Warning	Data not compensated for latency
4.8.3	Alarm	Integrity failed
4.9.1	Alarm	Invalid, corrupt or unavailable data required for essential information or for a required control function
4.9.1	Alarm or warning	Invalid, corrupt or unavailable non- essential information
4.9.2	Alarm	Integrity verification not possible when in active control mode (INS(C))
4.9.2	Warning	Integrity verification not possible when in other modes than active control mode (INS(C))
4.12.1.3	Alarm	Failure of one part requiring immediate attention
4.12.1.3	Alarm or warning	Failure of one part not requiring immediate attention
4. 12.1.4	Alarm	Malfunctions leading to automatic change of configuration or mode
4.13.5	Alarm	Back-up officer alarm as per individual standards

ISBN 2-8318-XXXX-X

ICS 47.020.70

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND